EXHIBIT 14

PSTN Services Migration to IMS Are SPs finally reaching the tipping point for large scale migrations?

Jean-Philippe Joseph

Abstract -- **Over the past decade, wireline Service Providers (SP) have been looking for ways to evolve the existing PSTN network to Next Generation Network (NGN). The economics of the PSTN migration to NGN could not result in a positive business case for SPs. However, new market conditions are squeezing SPs' margins for traditional voice services in the PSTN. Meanwhile, recently standardized IP Multimedia Services (IMS) based solutions coupled with sensible migration approaches offer new opportunities for SPs to cost-effectively migrate the PSTN. This paper examines the SP's needs, the services architectures and platforms, the access technology alternatives, the inherent PSTN interworking requirements that need to be supported during the transition, and pending implementation challenges. It further leverages learnings from recent engagements with SPs globally to propose solutions that will help accelerate the migration of PSTN services to IMS. Finally, it concludes that maintaining the status quo has increasingly become cost-prohibitive for SPs, and that the industry has reached the tipping point for large scale migrations of the existing PSTN services to IMS.**

Index Terms – **IMS, Softswitch, PSTN, Migration, VoIP**

I. INTRODUCTION

OVER the past decade, wireline Service Providers (SP) have been looking for ways to cost-effectively evolve the existing PSTN network to Next Generation Network (NGN). Many factors ranging from new technology immaturity, costs of migration, and complexity of integration have impeded the decision making process to migrate the PSTN network to NGN. Underpinning these considerations is the industry's inability to identify a clear set of new applications that could justify the investments required to migrate to NGN with a positive Return On Investment (ROI).

Recent efforts [1], [2], however, in the Telecommunication and Internet converged Services and Protocols for Advanced Networking (TISPAN) standards body have adapted the IP Multimedia Services (IMS) framework defined by the Third Generation Partnership Project (3GPP) [3] to wireline SP's applications and services. As a result, IMS has finally emerged as the prevalent consensus in the telecom industry for a target NGN that supports PSTN emulated and simulated voice services and multimedia applications. This paper examines the SP's needs, the services architectures and platforms, and the access technology alternatives for migrating the PSTN network to IMS. It further leverages experiences from recent engagements with SPs globally to propose solutions that will help accelerate the migration of PSTN services to IMS. Finally, it concludes that the industry has reached the tipping point for large scale migrations of the existing PSTN services to IMS.

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II. MOTIVATION FOR PSTN SERVICES MIGRATION

Over the past few years, wireline SPs have consistently experienced significant PSTN services revenue decline and line losses. As this trend continues, a new challenge is emerging as well: the cost of maintaining the remnant embedded base PSTN network is increasing while qualified maintenance personnel is retiring and leaving the workforce. A SP in Europe projects that its cost per line will triple over the next 5 years, if it continues to maintain the status quo. The combined effect of these trends results in a margin squeeze that is untenable over the long term.

Meanwhile, a clear goal for SPs is to evolve to a NGN environment with a lower cost structure and opportunities for offering new revenue-generating services (e.g., FMC, converged multimedia services). Standards work, recently completed in TISPAN for wireline network evolution, has prompted SPs to adopt the IMS architecture and framework for the target NGN.

However, many challenges have impeded large scale deployments of IMS, thus far. The industry has identified and developed several NGN applications (e.g., multimedia messaging, active phone book), but there is no convincing evidence that these services will bring in revenues fast enough to justify the investments in IMS. In addition, the traffic that these NGN applications will generate is expected to be low initially, resulting in a high unit cost for SPs. Therefore, the PSTN migration becomes necessary to bring more traffic in IMS, and hence, to help lower the NGN unit cost. As there will not be additional voice revenues associated with the migration of the PSTN voice services to IMS, the main challenge remains for SPs to find a cost-effective way to migrate the PSTN

III. MINIMIZING PSTN MIGRATION COSTS

Several strategies can help reduce the PSTN migration costs significantly for SPs. This section highlights four of such strategies:

1. Coupling PSTN migration with broadband access transformation leveraging Multi Service Access Node (MSAN) for POTS termination. By appropriately deploying voice-capable MSANs, SPs can exploit the synergies between PSTN migration and broadband access transformation and minimize their investments.
2. Keeping some legacy services in a consolidated PSTN environment that can be accessed through interworking mechanisms to minimize upfront investments in the IMS network, and lower the overall PSTN migration cost.
3. Discontinuing services with diminishing value add. Examples of such services might include: coin, ISDN BRI, and low bit-rate data services
4. Targeting low churn areas first to protect the PSTN revenues in stable markets while lowering the SP's cost structure with the migration to IMS. However, in less stable markets, SPs should promote a lower-cost VoIP

service over broadband in order to protect some portions of the revenues that otherwise would have gone to the competition.

IV. KEY QUESTIONS FOR PSTN MIGRATION

This section succinctly discusses key questions and challenges that SPs face in deciding on the best way to migrate the PSTN to IMS. SPs have different needs and constraints, and serve different markets and operate in different regulatory environments, and therefore, it is difficult at best to come up with one answer or solution that applies universally. However, the findings and insights presented here, which we developed through various engagements with SPs across the globe, tend to be generally common.

A. Should SPs Replicate All PSTN Services in IMS?

SPs realize that replicating all PSTN features in IMS is cost prohibitive. In fact, no vendor plans to develop in IMS the full feature set available in the PSTN. Hence, full feature transparency with the PSTN is unachievable. As a result, SPs will need to find ways to leverage the set of features available in IMS, and use innovative strategies to close any gaps. The following sections summarize SP's potential strategies and recommendations for services migration.

1. Services Migration Strategies

There are several strategies that SPs are considering when migrating the PSTN services to IMS:

- **Service Emulation** – Provide PSTN/ISDN service capabilities and interfaces using adaptation to an IMS infrastructure.
- **Service Simulation** – Provide PSTN/ISDN-like service capabilities using session control over IP interfaces and infrastructure.
- **Crossover Service** – This strategy allows SPs to initiate a request for services in one network (e.g., PSTN), but to cross over to the other network (e.g., IMS) for service fulfillment.
- **Service Elimination** – Eliminate PSTN features that are irrelevant in today's environment.

2. Services Migration Recommendations

SPs are using all of the above strategies to meet their customers' and regulatory requirements. However, by in large, the general approach for PSTN services migration is as follows:

- **Migrate the basic and supplementary services that are available in IMS** using PSTN emulated strategy.
- **Leverage existing IN services in IMS** using a crossover strategy. SPs made huge investments in the IN to support value-generating services such as--free phone, LNP, CNAM, Prepaid, Televoting, Calling Card, VPN etc.--that they would want to leverage.
- **Reuse PSTN assets that are critical to support emergency services.** For instance, in North America (NAR), *E911* emergency calls initiated in IMS are handled through a hybrid IMS/PSTN arrangement. New servers such as E-AS and VoIP Positioning Center (VPC) are introduced to support nomadicity and VoIP positioning service in IMS. However, once a caller is associated with a location, his/her E911 call is routed to selective routers in the PSTN, which provide the connectivity to the Public Safety Answering Points (PSAP) for emergency personnel assistance.
- **Keep in PSTN services that are not economical to migrate to IMS.** One such example of services identified in the NAR market is Operator Services (OS). Hence, IMS-originated OS calls should be force routed to OS switches in the PSTN for processing.
- **Promote service substitution for services that SPs plan to discontinue.** For instance, ISDN BRI (or BRA) penetration is relatively small globally. Hence, SPs should rather promote ISDN substitution with richer IP Centrex offers, and broadband access lines for high speed data services.

B. Can SPs Completely Retire the PSTN Network?

SPs should consolidate assets in the PSTN that are not economical to migrate to IMS, and defer investments in IMS that are not likely to produce returns. As a result, it is expected that a small overlay PSTN footprint will coexist with IMS in order to support critical PSTN services not available in IMS. The consolidated overlay PSTN remains operational until these services become irrelevant in the market place. Hence, in this section we address the follow-on two salient questions:

- Which PSTN assets SPs can eliminate? All existing circuit-switched assets, except those supporting services/functions that SPs plan not to replicate in IMS, are candidate for replacement. This includes: Class 5 end-office switches, remote switching modules as well as the remote digital terminals or digital loop carriers, the Local-/Access tandem switches, and the Class 4 toll switches. These circuit-switched assets will eventually be replaced with a common IP core, NGN access elements providing access to the common IP core, and access/network gateways controlled by a distributed call control.
- Which PSTN assets SPs should keep in place? Assets supporting critical services/functions that SPs plan not to replicate in IMS and special services will remain in the PSTN. For instance, OS switches should be consolidated in the PSTN to continue to provide this value-added service for SPs. Finally, SPs should plan to leverage the existing IN network and defer as much as possible the investments required to redevelop in IMS many value-added services they currently and cost-effectively offer to their customers.

C. What's the Best Approach for Migrating the PSTN to IMS?

This section discusses the solution alternatives available for SPs to transform the PSTN network to IMS. The PSTN network transformation encompasses various access technologies and call control architectures for supporting both POTS and ISDN services in IMS. We assess the solution alternatives and identify their domains of applicability in order to formulate recommendations for SPs. Finally, we discuss key IMS/IN interworking technical challenges for leveraging the existing IN network in IMS.

1. POTS and ISDN

As stated before, SPs are investing in new technologies for transforming the access network and positioning themselves for

multi-play service offerings. These access technologies include the following:

- xDSL
- Fiber to the Node (FTTN)
- Fiber to the Business/Building (FTTB)
- Fiber to the Home (FTTH)

We discuss the POTS/ISDN services migration in the context of the ongoing broadband access transformation programs.

Access Solution Alternatives and Requirements

The access solutions discussed below support emulated POTS/ISDN [4] as well as simulated voice services over broadband access. The corresponding service logic and features reside in the Telephony Application Server (TAS), which might invoke capabilities in the existing IN network in support of cross-over services. In this case, the MGCF/SGW provides the interworking functions between IMS and the IN network. Figure 1 below depicts the access solution options available for SPs.

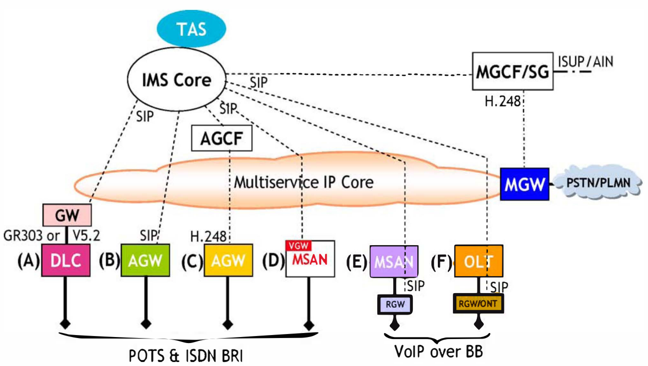

FIGURE 1: Access Solution Alternatives for POTS and VoIP

Option A: Digital Loop Carrier (DLC) Gateway – This option places a V5.2 (or GR303) gateway on the network side of an existing DLC, thus eliminating the need to migrate the subscriber loops. Rather, the V5.2 (or GR303) line is migrated to the gateway away from the TDM host switch.

Option B: SIP-Based Access Gateway (AGW) – Option B is a replacement solution in which the subscriber loops are migrated to a newly deployed AGW, which is fully dedicated to support voice applications. The AGW is a call-control-aware SIP gateway, which provides the traditional line functions of a DLC and terminates SIP messages on behalf of the analog endpoints that the AGW supports.

Option C: H.248-Based AGW with AGCF – Option C is similar to Option B, except that the AGW supports H.248 control protocol and not SIP. A call-control-aware Access Gateway Control Function (AGCF) is used to provide the H.248 and SIP interworking function. The AGW in this option is call agnostic and only relays state changes to the AGCF and the TAS for control.

Option D: MSAN with Integrated Voice Gateway – Option D takes advantage of a MSAN, which is deployed to support broadband applications. The MSAN can also be equipped to provide an integrated voice gateway (VGW) function for PES. Analog loops are migrated onto voice cards in the MSAN for PES access. The MSAN can also simultaneously support other broadband access services (e.g., xPON, xDSL). As a result, the cost of supporting voice services is shared across all applications supported on the MSAN. As in Options B and C, the VGW can either be SIP-based or H.248-based.

Option E: MSAN for xDSL and FTTN with Residential Gateway – Option E is a POTS/ISDN simulation solution. It provides simulated VoIP services over broadband access. The MSAN supports broadband access technologies such as: xDSL and FTTN. On the CPE side, a Residential Gateway (RGW) (a.k.a. as Analog Telephone Adapter (ATA)) allows the analog phone to be connected to the broadband line.

Option F: xPON for FTTH with Optical Network Terminal (ONT) and RGW – Option F is similar to Option E except that its access technology is based on xPON. For greenfield deployments in new development areas, and in areas where SPs plan to lay fiber to the home, simulated VoIP using a RGW is a viable solution. SPs should consider promoting commercial migration of simulated VoIP services and offering a bundle of voice, data video services at an attractive price to the subscribers.

Last, for support of ISDN BRI, although the development of an ISDN card similar to the POTS cards in Option D is feasible, at this point no announcement has been made in the industry on the availability of such a product. Meanwhile, SPs with a sizeable embedded base of ISDN BRI customers are exploring CPE-based solutions for evolving ISDN BRI over DSL lines. These solutions require deployment of an ISDN over IP (ISDNoIP) gateway at the CPE. The ISDNoIP gateway will combine the following functions: 1) DSL termination; 2) Internet Access Device (IAD); and, 3) ISDN over IP adaptation.

Recommendations

Option D is the recommended access solution for POTS migration to IMS. The analog loops are migrated to an MSAN equipped with VGW so the SPs can retire the Cl5 EO and DLC equipments. This solution applies to both curb locations and COs. The MSAN also supports other broadband access applications (e.g., xDSL, xPON) making it possible to achieve network convergence on access without discontinuity in service offerings. Finally, in situations where there is a small number of POTS lines that need to be migrated off the PSTN, SPs should consider leveraging option E by providing a RGW, and subsidizing a cheap broadband access line (e.g., ADSL) for the subscriber. However, this is not a cost-effective strategy for large scale migrations.

With respect to ISDN BRI, we recommend that SPs promote service substitution based on VoIP, rich IP Centrex services and broadband lines for high speed internet access.

ISDN PRI

ISDN PRI is very popular globally and is used to support enterprises' voice, data, and video communications services. Today, most non-VoIP PBXs are connected to Class5 and Class4 central office switches using ISDN PRI over T1/E1 facilities. In general, the architecture alternatives for ISDN PRI fall into two categories: 1) ISDN PRI Emulation; and 2) ISDN PRI Substitution. The former is used to minimize the impact on the customer premise equipment (CPE), whereas the latter requires changes to the CPE.

Recommendations

- SPs should promote ISDN substitution as much as possible, and offer attractive programs for commercial migration of ISDN PRI customers to new business VoIP services (e.g., IP Centrex), and SIP trunking. This will primarily target new business customers without a legacy PBX, and existing customers who are willing to evolve their legacy PBXs with IP interfaces.
- For PBX customers who are not ready to evolve the CPE to IP, SPs will continue to support PBX access over TDM facilities. In this scenario, the PRI trunk will terminate on a centralized gateway deployed at a SP's POP location, with minimal impact to the customer.

2. Call Control Architecture

Most SPs have already deployed a pre-IMS Softswitch-based (a.k.a. nodal softswitch) (SS) solution for offering VoIP service over broadband access. In general, earlier generations of SS do not support PSTN emulated services, although they can interwork with the PSTN to offer key business and regulatory features. In this section, we present the call control options for SPs', assuming that a SS is already deployed to support VoIP, and not PSTN emulated services.

Architecture Options

This section assesses the call control evolution to IMS from the viewpoint of a coexisting SS-based VoIP call control platform as an overlay to the PSTN, representing the embedded base. Hence, the options for the call control evolution are as follows:

Option A: Use the existing SS for growth and replacement with all IN triggers implemented on the SS. This is the equivalent of a target point solution for voice.

Option B: Existing SS for growth and PSTN replacement with an overlay IMS core dedicated to support non-voice-NGN services. This option implies that all triggers to the existing IN networks are placed on the SS. The SS and IMS core interworking is outside the scope of this paper.

Option C: Cap existing SS and support all growth and PSTN replacement on an overlay IMS core. For this option, the IN triggers are implemented on both the SS and the IMS core in support of their respective endpoints. However, NGN services in the IMS domain can be leveraged only to VoIP endpoints in the IMS domain, and not in the SS domain.

Option D: Deploy an overlay IMS core for all growth and replacement of both the SS and the embedded base PSTN. The IMS core implements the triggers for IN interworking.

Option E: Similar to Option E, except that the SS components (e.g., MGC, SG) are integrated into the IMS core

Recommendations

A converged IMS core, as defined in Option E, is the recommended target call control platform. The converged IMS core supports all voice and non-voice applications for both consumer and business customers.

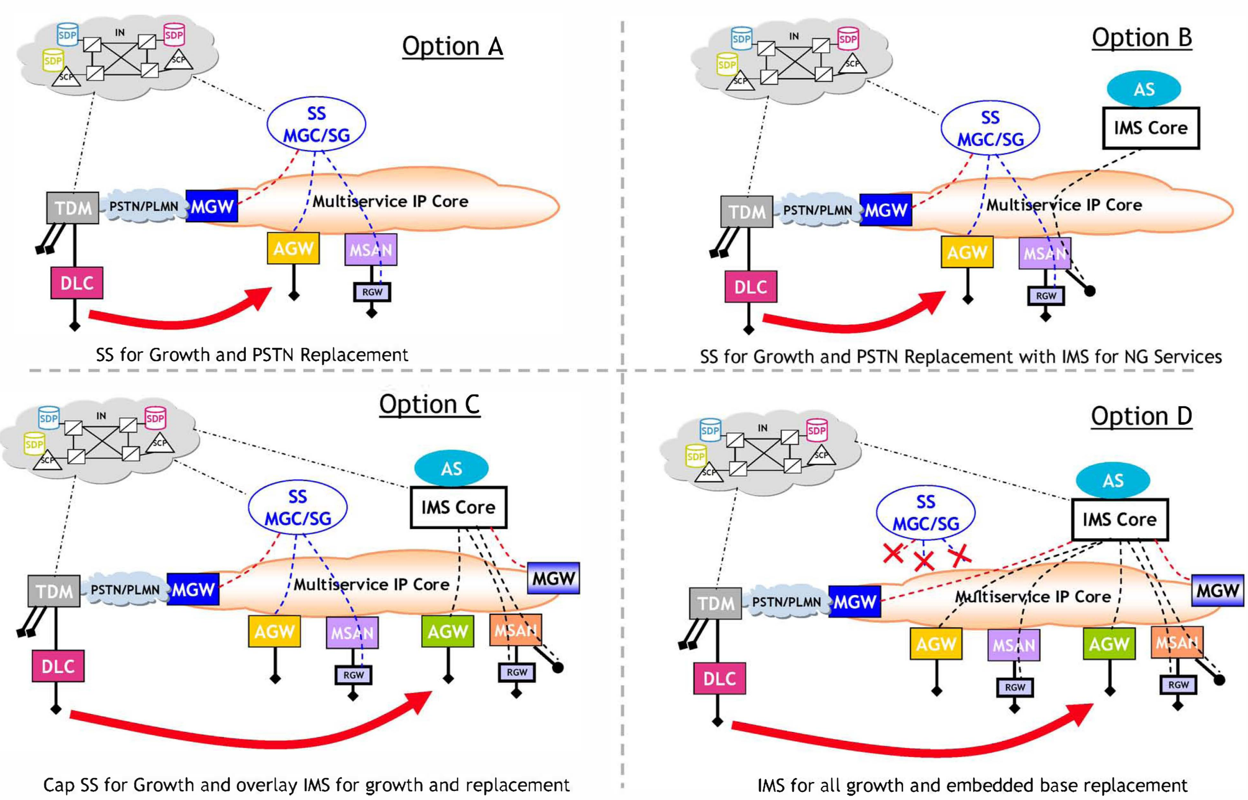

FIGURE 2: Call Control Architecture Options

That said, SPs that initially deployed a SS platform that has an evolution path to be integrated with an IMS core will go through a less complex transition when they decide to evolve to IMS. However, we see no long-term benefits for SPs to deploy a new SS platform as a stepping stone to IMS. In fact, we recommend that SPs simply deploy an IMS core, and avoid the mandatory step of transitioning later on the SS platform to an IMS core.

The benefits of deploying a converged IMS core for PSTN migration include the following:

- CapEx and OpEx of a converged call control platform are lower compared to the "stovepipe" implementations requiring management of multiple domains.
- A converged call control platform will help SPs enhance their revenues. It positions the SPs for integrating traditional and next generation applications in order to A converged call control platform will help SPs enhance their revenues. It positions the SPs for integrating traditional and next generation applications in order to offer new and differentiated services such as: converged fixed-mobile, presence- and location-based services.

3. IN Interworking

Finally, we recommend the re-use of the existing IN network for IMS in the short and intermediate terms, as depicted in Figure 3. The existing IN network supports IN-based services not available in IMS and can lead to significant CapEx and OpEx savings for the SPs. These services are highly integrated with SP's OSS/BSS processes and infrastructure (e.g., service creation, billing). Hence, by leveraging the IN elements, SPs can avoid the costs of redeveloping these services in IMS. Moreover, it is also possible to consolidate development resources and training, reducing operational costs. From the network perspective, the existing IN platform allows for sharing of common functions such as NP, free phone service and the development of common operational processes. This will simplify network evolution, management and growth, as well as the migration process, as subscribers are moved from one service offering domain to another.

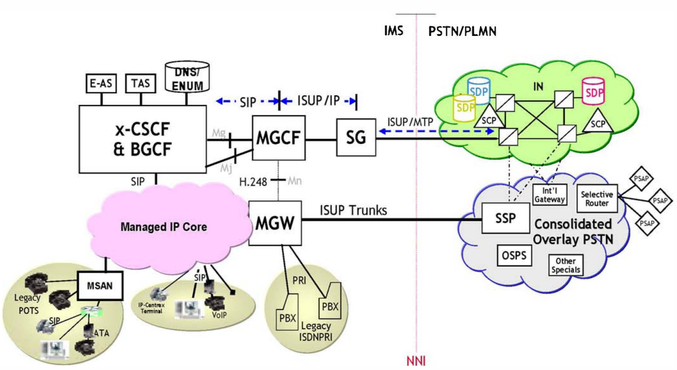

FIGURE 3: IMS/PSTN Interworking

V. HOW TO EVOLVE TO A TARGET IMS?

We recommend a gradual migration of the PSTN network to IMS. This approach will help SPs in the following ways: 1) avoid making huge investments upfront by introducing capabilities in steps, and consequently spreading the necessary investments over time; 2) ensure that the migration has little impact as possible on existing customers in order to minimize churn; and, 3) minimize the risks of migrating a large number of PSTN lines that might end up churning away to competition. This section outlines a possible high-level evolution roadmap for a prospective wireline SP.

The migration steps are as follows:

a. Deploy a new broadband access platform in conjunction with a distributed overlay IMS core for call control, TAS for emulated PSTN services and MGW for PSTN bearer interworking.
b. Leverage IN capabilities in IMS through interworking at the MGCF/SG
c. Migrate the POTS lines to the broadband access platform and ISDN PRI to a centralized PRI MGW.
d. Decommission corresponding Cl5 EO, Cl4 and tandem switches.
e. Enable enhanced routing features in support of Cl4 functions, build QoS capabilities based on Resource Admission Control Sub-system, and introduce geo-redundancy
f. Implement the I-BGF/BCF for bearer/signaling peering with other IMS networks [3] and [5]
g. Finally, consider IN migration/integration into IMS

VI. CAN SPs ACHIEVE A POSITIVE BUSINESS CASE FOR PSTN MIGRATION TO IMS?

This section summarizes the financial results of a study conducted for an incumbent SP migrating its embedded base PSTN to an IMS based network. The PSTN migration is done according to the solutions and principles discussed in this paper. All financial numbers are non-discounted. The planning horizon is assumed to be 5 years. Chart 1 below shows the following results:

- The capital investment (CapEx) that the SP incurs for deploying and growing the NGN network to support the migrated POTS/ISDN lines. By 2012, the NGN network has enough capacity to support the remaining portion of the PSTN the SP migrates with minimal investment.
- The operations expenses (OpEx) for maintaining both the NGN and the remaining part of the PSTN that has yet to be migrated. As the SP migrates the POTS lines to the NGN, corresponding assets in the PSTN are decommissioned. Moreover, the SP continues to experience line drops in the PSTN, which result in further decommissioning of TDM assets. Furthermore, the SP incurs expenses for migrating (physical migration off the PSTN to, and reprovisioning in IMS) the PSTN lines to the NGN. However, the SP sees a reduction in the ongoing OpEx per line in the NGN, mainly attributed to a much simplified operations, reduction of maintenance personal and power consumption in the NGN. The combined effect of growing the IMS network while decommissioning the PSTN results in a net OpEx reduction for the SP.

The challenge for the SP, however, is to be able to pay for the additional CapEx associated with the NGN deployment with the OpEx savings it realizes by gracefully scaling down the PSTN over the study period.

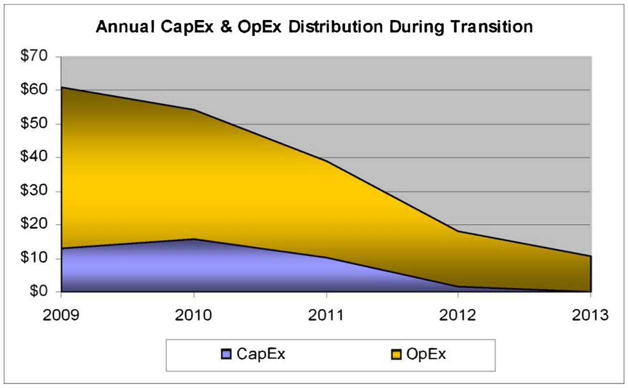

CHART 1: Non-Discounted Annual CapEx and OpEx Distribution ($M)

Chart 2 summarizes the comparative OpEx breakdown for the Present Mode of Operations (PMO) (continuing with the PSTN) relative to the Future Mode of Operations (FMO). It shows that the SP will be able to realize OpEx savings on the order of 24% (or $42M) over 5 years.

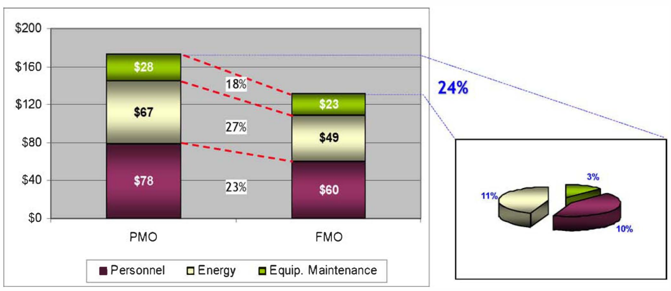

CHART 2: Comparative OpEx Breakdown & Savings Distribution ($M)

The overall OpEx savings are distributed as follows:

- Power consumption reduction: 27% (or 11% of total savings)
- Operations Personnel: 23% (or 10% of total savings)
- Equipment Maintenance: 18% (or 3 % of total savings)

As demonstrated in this case, a major area of savings for the SP is power consumption reduction. A typical TDM EO switch consumes about 2.3 Wh per POTS line* (8 Wh for ISDN BRI line), whereas for a typical MSAN the estimated power consumption is about .43 Wh per PES line.

In short, this PSTN migration to IMS case study proves-in for the SP. On a discounted basis, the SP was able to breakeven in 5-years. This case was conservative in that it did not include other impacted areas of expenses such as: floor space, air-conditioning costs, closing down of offices, which would have resulted in further OpEx savings for the SP.

VII. SUMMARY AND CONCLUSION

This section summarizes the key challenges and benefits for SPs that plan to migrate the PSTN to IMS and the recommendations for a cost-effective migration:

- The PSTN migration is necessary to help SPs lower their overall cost structure. Migrating the PSTN traffic to NGN will increase the utilization in NGN and help SPs' lower NGN cost structure
- SPs are rolling out major broadband access transformation programs. A strategy that couples the PSTN migration and the access transformation will help minimize the PSTN migration costs. SPs should exploit synergies of using the broadband access nodes to terminate analog loops
- Full PSTN feature transparency in NGN is cost-prohibitive and unnecessary
- We see no viable "scorched earth" PSTN migration strategy. A seamless co-existence of IMS with some consolidated/integrated parts of the PSTN is a more realistic target over the short and intermediate terms
- A key limitation in the delivery of hybrid services is the distribution of point codes in IMS. SPs would prefer not to assign a point code to each TAS deployed in IMS in addition to the one assigned to the signaling gateway. In a multi-TAS implementation, the mechanisms for allowing the SG to distribute incoming messages to the appropriate TAS are lacking
- A staged migration to a target converged IMS architecture is recommended

In conclusion, we believe that maintaining the status quo has increasingly become cost-prohibitive for SPs. As the number of PSTN lines continues to drop as a result of wireless substitution and VoIP over broadband adoption, SPs need to transform the legacy PSTN network with new technologies to lower their cost structure. IMS has emerged as the prevalent consensus in the telecom industry for a target NGN. Strategies that couple the PSTN migration with broadband access transformation can significantly reduce the cost of migration and is proven to result in a positive business case for SPs. Therefore, we conclude that the industry has reached the tipping point for large scale migrations of the PSTN services to IMS.

ACKNOWLEDGEMENTS

The author would like to thank several colleagues for sharing their insights and providing comments on many aspects of this paper. In particular, he is grateful to: Mohamed El-Sayed, Tim Connelly, Michel Grech, Bob Novo, and Morgan Stern.

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* Assuming usage of 50 mErl per line during busy hour